REMARKS

Claims 1-67, 74-79, and 81-84 are pending. No claim amendments are made herein.

I. The Drawings.

Better quality drawings are respectfully submitted herein. No new matter is added. The drawings submitted herein overcome the draftperson's objections.

II. Itoh, US 5,497,433 does not anticipate claim 1 at least because an input hologram is not being compared in Itoh.

Claim 1 claims:

1. (Original) A method of pattern recognition comprising:

generating a hologram of a reference object;

generating a hologram of an input object; and

correlating the hologram of the reference object with the hologram of the input object to generate a set of correlation peaks.

The USPTO respectfully alleges that Itoh teaches the above claimed steps. However, this is respectfully incorrect because Itoh is not correlating a "hologram of a reference object" to another "hologram of an input object" because comparing holograms to holograms is applicants' novel and useful idea and is not known in the art. It is noted that a "hologram" *per se* includes3D image information by definition:

"**hologram:** a three-dimensional image reproduced from a pattern of interference produced by a split coherent beam of radiation (as from a laser); *also* **:** the pattern of interference itself.

Source: *Merriam-Webster Medical Dictionary, © 2002 Merriam-Webster, Inc.*

For example, applicants' invention may be used for 3D image recognition by comparing a recorded hologram to a reference hologram. Nothing like this is disclosed in

Itoh which merely deals with known 2D optical image processing which involves "irradiance mapping" and ***does not contain the phase and amplitude information of a hologram of the input object.*** Thus, the difference between Itoh and claim 1 is akin to the difference between regular 2D photography which is an irradiance mapping onto a flat paper and holographic photography which is 3D because it reconstructs the phase and amplitude of an original wave coming from an object so it appears to have the natural real world 3D depth when it is displayed.

Thus, a "hologram" includes3D image information by definition and Itoh at Fig. 1b is only dealing with 2D images taken by a 2D TV camera. In contrast, a hologram (3D (x,y,z) by definition) as shown in Figure 1 may be taken or recorded by a phase shifting interferometer to record a digital hologram of an object at a three dimensional "z" distance "d" from a CCD array. In short, Itoh is merely dealing with 2D optical information processing or 2D irradiance control as is well known and thus its' television camera cannot take or record a holographic picture.

This is clearly shown at cited Col. 2, lines 50-53 of Itoh, ***wherein Itoh takes a 2D input image f(x,y) of an object with a TV camera*** and then performs a Fourier transform of this 2D image. This is described in detail at Col. 4 of Itoh. ***In fact it is respectfully noted that there are no input image holograms anywhere described in Figure 1b of Itoh because Itohs' 2D TV camera cannot record a holographic image as can the interferometer arrangement in present Figure 1.***

Thus Itoh's 2D system is very different from claim 1 which begins by generating or taking a "hologram" of a reference object which is a 3D image by definition, and then also which also generates a hologram of a reference object. See page 6 of the present specification wherein it is stated:

> "The complex amplitude given by Eq. (1) is measured by recording four interferometric patterns, or ***holograms,*** $I_n(x, y; \alpha_n) = |H_O(x, y) + R(x, y; \alpha_n)|^2$.
>
> ***The holograms,*** $I_n(x, y; \alpha_n)$, formed by the combination of $H_O(x, y)$ and $R(x, y; \alpha_n)$ are recorded digitally, or on film, as a hologram at the output plane 210.

Thus, it is respectfully asserted to be clear that holograms as claimed are different from merely performing a fourier transform on a 2D input image as described in Figure 1b of

Itoh. However, the USPTO states that Itoh generates a hologram of an input object, but this is an incorrect reading of the reference. ***Generating a hologram of an input object is not taught at the cited Col. 2, lines 50-53 where no such input hologram is formed but rather a 2D input image is recorded by a TV camera.***

Additionally, Itoh discusses using "computer generated holograms" but this is in reference to performing a coordinate transformation of the input image to a rotational invariant and scale-invariant polar coordinate system. This has nothing to do with comparing an actual input hologram to a reference hologram for example. Thus, this commonly used "Fourier transform hologram" where two Fourier transforms of 2D images are superimposed is not the same as the limitations of claim 1 where an input hologram is recorded from the outset. ***Applicants have also enclosed a passage from Hecht "Optics" that discusses "computer generated holograms" and their use as "Holographic Optical Elements" HOE's with an example of character recognition of a printed word on a page using a HOE so that the Examiner can respectfully appreciate the difference.***

Thus, applicants' invention may be used for image recognition of phase only or complex amplitude objects (such as biological samples) by comparing a recorded hologram to a reference hologram. Nothing like this is disclosed in Itoh which merely deals with intensity or the "irradiance distribution" of 2D images for optical image processing.

The other independent claims, 8, 16, 23, and 46, also claim generating a hologram of an input object and they are therefore also allowable. The dependent claims are thus also allowable. Therefore, all of the claims are believed to be in condition for allowance.

III. Conclusion.

In view of the foregoing, it is respectfully submitted that the instant application is in condition for allowance. Accordingly, it is respectfully requested that this application be allowed and a Notice of Allowance issued. If the Examiner believes that a telephone conference with Applicants' attorney would expedite this case, the Examiner is respectfully requested to telephone the undersigned for any reason.

In the event the Commissioner of Patents and Trademarks deems additional fees to be due in connection with this application, Applicants' attorney hereby authorizes that such fee be charged to Deposit Account No. 06-1130.

Respectfully submitted,

CANTOR COLBURN LLP

By: Daniel P. Lent

Daniel P. Lent
Registration No. 44,867
CANTOR COLBURN LLP
55 Griffin Road South
Bloomfield, CT 06002
Telephone (860) 286-2929
Facsimile (860) 286-0115
Customer No. 23413

Date: November 24, 2004

Enclosure Hecht "Optics" p. 609-610.

In the Drawings:

Replacement sheets for all of the drawings are included herein, sheets 1-10.

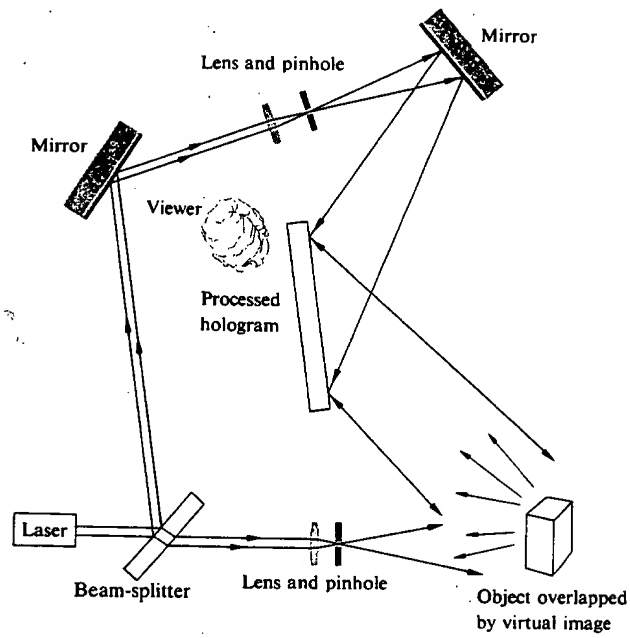

Figure 14.54 Real-time holographic interferometry.

iii) Acoustical Holography

In acoustical holography, an ultra-high-frequency sound wave (ultrasound) is used to create the hologram initially, and a laserbeam then serves to form a recognizable reconstructed image. In one application, the stationary ripple pattern on the surface of a water body produced by submerged coherent transducers corresponds to a hologram of the object beneath (Fig. 14.55). Photographing it creates a hologram that can be illuminated optically to form a visual image. Alternatively, the ripples can be irradiated from above with a laserbeam to produce an instantaneous reconstruction in reflected light.

The advantages of acoustical techniques reside in the fact that sound waves can propagate considerable distances in dense liquids and solids where light cannot. Thus acoustical holograms can record such diverse things as underwater submarines and internal body organs.* In the case of Fig. 14.55, one would see something that resembled an x-ray motion picture of the fish. Figure 14.56 is the image of a penny formed via acoustical holography using ultrasound at a frequency of 48 MHz. In water that corresponds to a wavelength of roughly 30 μm, and so each fringe contour reveals a change in elevation of $\frac{1}{2}\lambda$ or 15 μm.

* See A. F. Metherell, "Acoustical Holography," *Sci. Am.* **221**, 36 (October 1969). Refer to A. L. Dalisa et al., "Photoanodic Engraving of Holograms on Silicon," *Appl. Phys. Letters* **17**, 208 (1970), for another interesting use of surface relief patterns.

iv) Holographic Optical Elements

Evidently when two plane waves overlap, as in Fig. 14.42, they produce a cosine grating. This suggests the rather obvious notion that holography can be used for nonpictorial purposes, like making diffraction gratings. Indeed the *holographic optical element* (HOE) is any diffractive device consisting of a "fringe" system (i.e., a distribution of diffracting amplitude or phase objects) created either directly by interferometry or by computer simulation thereof. Holographic diffraction gratings, both blazed and sinusoidal, are available commercially (with up to around 3600 lines/mm). Although still less efficient than ruled gratings, they do produce far less stray light, which can be important in many applications.

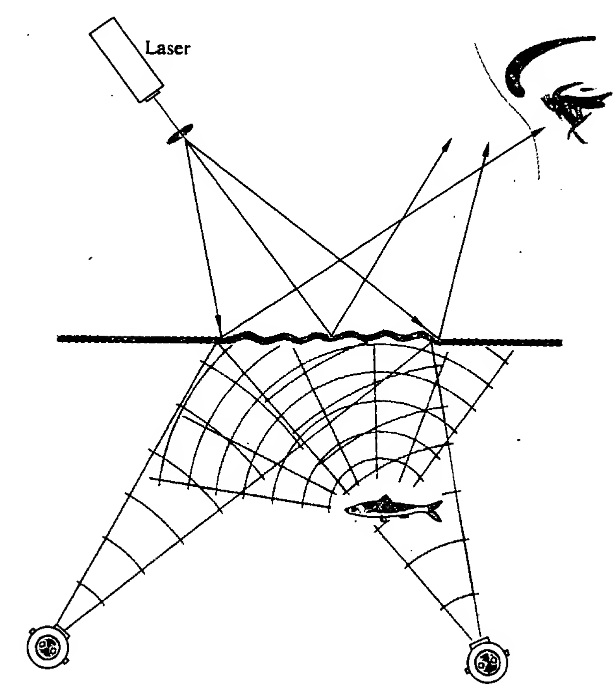

Figure 14.55 Acoustical holography.

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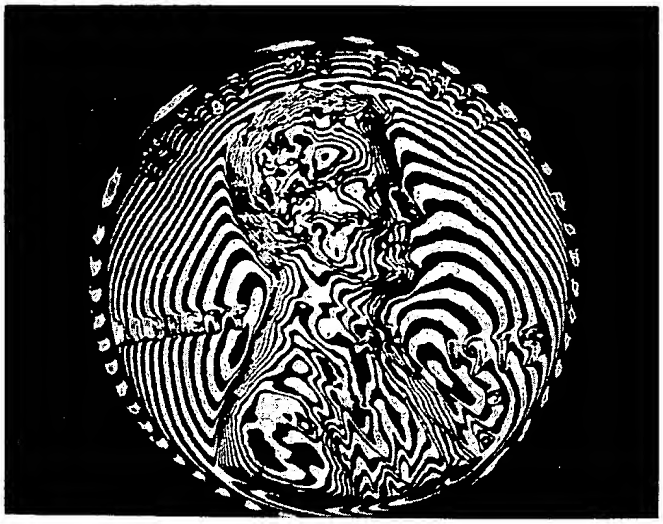

Figure 14.56 Interferometric image of a penny via acoustical holography. (Photo courtesy Holosonics, Inc.)

Suppose we record the interference pattern of a converging beam using a planar reference wave. Upon reilluminating the resulting transmission hologram with a matching plane wave, out will come a recreated converging wave—the hologram will function like a lens (see Fig. 14.39). Similarly, if the reference beam is a diverging wave from a point source and the object is a plane wave, the resulting hologram, reilluminated by the point source, will play back a plane wave. In this way a holographic optical element can perform the tasks of a complex lens with the added benefit of allowing for an inexpensive, lightweight, compact system design. Holographic optical elements are already in use inside supermarket check-out scanners that automatically read the bar patterns of the Universal Product Code (UPC) on merchandise. A laserbeam passes through a rotating disk composed of a number of holographic lens-prism facets. These rapidly refocus, shift, and scan the beam across a volume of space, ensuring that the code will be read on the first pass across the device. HOEs are used in so-called heads-up displays in airplane cockpits. These allow reflected data to appear on an otherwise transparent screen in front of the pilot's face and yet not obscure the view. They're also in office copy machines and solar concentrators.

As *matched spatial filters,* HOEs are used in optical correlators (p. 505) to spot defects in semiconductors and tanks in reconnaissance pictures. In such cases the HOE is a hologram formed using the Fourier transform of the target (e.g., a picture of a tank or perhaps a printed word) as the object. Suppose the problem is to find a word on a printed page automatically, using an optical computer like that in Fig. 14.8, that is, to cross-correlate the word and the page of words. The target-transform hologram is placed in the transform plane and illuminated with the transform of an entire page of print. The field amplitude emerging from this HOE-filter will then be proportional to the product of the transforms of the page and the word. The transform of this product, generated by the last lens and displayed on the image plane, is the desired cross-correlation (recall the Wiener–Khintchine theorem). If the word is on the page, there will be a high correlation, and a bright spot of light will appear superimposed in the final image everywhere the target word occurs.*

It is possible to synthesize, point by point, a hologram of a fictitious object. In other words, in the most direct approach holograms can be produced by calculating, with a digital computer, the irradiance distribution that would arise were some object appropriately illuminated in a hypothetical recording session. A computer-controlled plotter drawing or cathode ray tube read out of the interferogram is then photographed, thence to serve as the actual hologram. The result upon illumination is a three-dimensional reconstructed image of an object that never had any real existence in the first place. More practically, computer-generated HOEs are now routinely being produced, often to serve as references for optical testing. Since this mating of technologies can in principle generate wavefronts otherwise essentially impossible to produce, the future is very promising.

14.4 NONLINEAR OPTICS

Generally, the domain of *nonlinear optics* is understood to encompass those phenomena for which electric and magnetic field intensities of higher powers than the first

* See A. Ghatak and K. Thyagarajan, *Contemporary Optics,* p. 214.